

Remarks

The above Amendments and these Remarks are in reply to the final Office action mailed July 7, 2006.

Currently, claims 1-6, 9, 10, 15-29, 31, 33-42, 47-52, and 54-62 are pending. Claims 1-6 are withdrawn from consideration. Claims 17-21 are objected to. Claims 9, 10, 15-21, 31, 33-42, 47-52 and 62 were rejected under 35 USC 103(a) as being unpatentable over Lee et al., US Patent No. 6,881,994 and Voutsas, US Patent No. 6,383,899. Claims 22-29 and 54-61 were rejected under 35 USC 103(a) as being unpatentable over Lee et al. and Voutsas and further in view of Park et al., US Patent No. 6,727,514. Applicants have amended claims 5, 9, and 17. Applicants respectfully request reconsideration of claims 9, 10, 15-29, 31, 33-42, 47-52, and 54-62.

I. Discussion of Claim Amendments

Claims 5 and 9 were each amended to add a comma which was obviously missing. These amendments correct obvious errors and do not change the scope of the claims. Claim 17 was amended to depend from claim 9 rather than from earlier cancelled claim 8. Neither of these amendments constitutes new matter.

I. Claim Objection: Claims 17-21

The Examiner correctly objected to claims 17 to 21 for depending from claim 8, which was cancelled in the response of May 25, 2006. In that response Applicants neglected to amend claim 17 (and thus its dependent claims 18-21) to depend from claim 9, rather than from cancelled claim 8, and have corrected this oversight in the present response. Applicants appreciate the Examiner's identification of this error.

II. 35 USC 103(a) Rejections Over Lee et al. and Voutsas

Claims 9, 10, 15-21, 31, 33-42, 47-52 and 62 were rejected under 35 USC 103(a) as being unpatentable over Lee et al. and Voutsas.

Claim 9 recites a method for crystallizing a polysilicon layer on a wafer, the method comprising: forming a first amorphous silicon layer; selectively introducing a crystallizing agent on the amorphous layer in a substantially symmetric pattern in two dimensions; and annealing the wafer to form the crystallized polysilicon layer, wherein substantially no amorphous silicon remains between silicon grains in the polysilicon layer, wherein the crystallizing agent is silicon nuclei, wherein the step of selectively introducing a crystallizing agent in a substantially symmetric pattern comprises: forming a mask layer on the first amorphous silicon layer; etching holes in the mask layer, the holes distributed in a substantially symmetric pattern and exposing portions of the first amorphous layer; and depositing silicon nuclei on the mask layer and the exposed portions of the first amorphous layer.

Regarding claims 9 and 10, the Examiner finds these elements in Lee et al., except:

Lee et al. do not show using germanium or silicon as the crystallizing agent. Voutsas teaches to use either silicon or germanium as crystallizing agents so as not to adversely affect the electronic properties of the silicon layer. It would have been obvious to a person of ordinary skill in the art at the time of invention to use either silicon or germanium as crystallizing agents as taught by Voutsas in the process and device of Lee et al. so as not to adversely affect the electronic properties of the silicon layer.

In the Response to Arguments section of the July 7 action, the Examiner explains that Applicants have not addressed the Examiner's assertion that Voutsas teaches the equivalence of silicon and germanium as crystallizing catalysts. Applicants understand that the Examiner is suggesting a) that Voutsas teaches that silicon and germanium are equivalent crystallizing agents, b) that Lee et al. propose germanium as a crystallizing agent, and thus c) that silicon could replace germanium as a crystallizing agent in the cited embodiments of Lee et al. Applicants will address this contention.

In several passages (eg. col. 32, lines 17-33; col. 45, line 59 to col. 46, line 57; col. 67, line 42-col. 69, line 50) Lee et al. suggest the use of transition metals, or germanium, as crystallization catalysts. This process is described by Lee et al. at col. 32, lines 22-33:

"If desired, catalyst induced crystallization may be used to improve the crystallinity of layer 4005. In this process, a catalyst element such as Ni, Ge, Mo, Co, Pt, Pd, a silicide thereof, or other transition metal elements, is placed in contact with the semiconductor layer 4005. Then, the layer 4005 is thermally and/or laser annealed. During the annealing, the catalyst element either propagates through the silicon layer leaving a trail of large grains, or serves as a seed where silicon crystallization begins. In the latter case, the amorphous silicon layer then crystallizes laterally from

this seed by means of solid phase crystallization (SPC).”

Voutsas discloses a quite specific and entirely different method of crystallization involving a distinct four-step process. The process of Voutsas (col. 3, lines 32-53) includes 1) depositing an amorphous silicon film, 2) partially crystallizing the film to form microcrystallite material adjacent noncrystallized regions, 3) implanting in the film ions of a preselected type at a preselected energy etc., selectively to *eliminate* preselected ones of the microcrystallite material particles, and further to amorphize the non-crystallized regions, and 4) annealing to complete crystallization.

Voutsas does indeed suggest that *for this specific four-step process*, either silicon or germanium can be used (eg., col. 5, lines 47-50) during the ion implantation step which serves to selectively annihilate earlier-formed microcrystals (col. 5, lines 44-47.)

Applicants will respectfully point out, however, that in contrast, in Lee et al., transition metals or germanium serve to provide a seed during solid phase crystallization. This process is unrelated to the destruction of microcrystallite material described by Voutsas. Applicant suggests it cannot be assumed that because silicon can substitute for germanium in the Voutsas process, the same substitution can be made in a metal-induced crystallization process employing an entirely unrelated mechanism.

For evidence that all materials cannot be considered equivalent in these very different processes, Applicants notes that at col. 5, lines 52-55, Voutsas specifically teaches that “metal elements, such as tin, aluminum, or *nickel*,” (emphasis added) should not be used, as they produce undesirable side effects. In contrast, in Lee et al., in every passage describing use of metal-induced crystallization, nickel is the first-named catalyst, and is clearly preferred (col. 68, lines 54-56). The processes are not equivalent, and the appropriate catalysts for each process cannot be assumed to be equivalent.

Further, Applicants point out that at col. 5, lines 57-60, of Voutsas, this ion implantation step is described as a “crystal-elimination step”. Voutsas is clear that the *overall* result of the four-step process is to improve crystallinity of the film, but it is not clear that the implanted silicon or germanium ions of Voutsas can accurately be described as crystallizing agents as recited in claim 9.

Claim 10 further recites forming a second layer of amorphous silicon *on and in contact with* the first amorphous silicon layer and the silicon nuclei.

Applicants cannot find, in Lee et al., a second amorphous silicon layer deposited *on and in contact with* the first amorphous silicon layer. An additional amorphous silicon layer may be deposited above the first silicon layer, but this additional silicon layer is nowhere taught as being on and in contact with the first layer.

Independent claims 31, 33, 47, and 62 similarly recite a second amorphous silicon layer on and in contact with the first amorphous silicon layer; thus their dependent claims 34-36 and 48-49 also include this limitation.

Claim 15 recites a method for crystallizing a polysilicon layer on a wafer, the method comprising: forming a first amorphous silicon layer; selectively introducing a crystallizing agent on the amorphous layer in a substantially symmetric pattern in two dimensions; and annealing the wafer to form the crystallized polysilicon layer, wherein substantially no amorphous silicon remains between silicon grains in the polysilicon layer wherein the crystallizing agent is laser energy wherein the step of selectively introducing a crystallizing agent in a substantially symmetric pattern comprises treating the first amorphous layer with a laser at locations distributed in a substantially symmetric pattern. Claim 50 has a similar limitation.

Lee et al. do not teach applying laser energy to an amorphous silicon wafer in a substantially symmetric pattern in two dimensions. The embodiments of Lee et al. (Fig. 65, for example, and col. 45, line 59-col. 46, line 48) that describe selective introduction of a crystallizing agent (in “crystallization windows”) teach, for example, the use of transition metals or transition metal silicides as crystallization catalysts (col. 46, lines 13-15), but do not teach the use of laser energy applied through these windows.

Claim 37 recites a method for maximizing grain size and controlling density of grain boundaries in crystallized silicon, the method comprising: forming a first amorphous silicon layer on a wafer; selectively creating nucleation sites at substantially uniform intervals on the first amorphous silicon layer; annealing the wafer to convert the amorphous layer to polysilicon; and forming a plurality of memory cells in the polysilicon, wherein portions of the cells comprise portions of the polysilicon, and *wherein placement of the nucleation sites and placement of individual memory cells is not coordinated.*

The Examiner has not specifically identified such a teaching in Lee et al. Applicants will point out, however, that in the embodiment of Lee et al. describing use of a crystallization window,

there is a specific teaching that word lines are formed over the regions where the crystallization windows were formed, and that channel regions of the TFTs (the memory cells) are located below the word lines (col. 46, lines 44-47), i.e. that placement of memory cells and placement of nucleation sites in fact *are* coordinated.

Another embodiment of Lee et al. employs metal-induced crystallization from seeding sites, or seeding windows (col. 68, line 29-col. 69, line 43). In this embodiment, however, Lee et al. also teach coordination of placement of the nucleation sites and memory cells (col. 69, lines 41-43):

Formation of devices in the region of the seeding windows 5424 should be avoided due to excessive transition metal contamination.

For clarification, Applicant will respectfully point out that claims 9 and 31 recite a crystallizing agent which is silicon nuclei, while claims 15 and 33 recite that the crystallizing agent is laser energy. No claim recites the use of *both* depositing silicon or germanium nuclei as crystallizing agents *and* crystallizing the regions using a laser, as in the Examiner's summary of the claim elements on paragraph 3 of the July 7 action (beginning on page 2 and continuing onto page 3.) Further, the claims do not recite "substantially removing the amorphous silicon," nor do Applicants find such teaching in the cited passage of Lee et al. (col. 32, lines 12-33 and col. 46, lines 13-47.)

Applicants have shown that silicon and germanium cannot be considered equivalent in the process of Lee et al. Lee et al. do not teach laser crystallization at uniform intervals, nor do Lee et al. teach formation of memory cells in a crystallized layer where placement of the memory cells is not coordinated with placement of nucleation sites. Applicants respectfully request reconsideration.

III. 35 USC 103(a) Rejections Over Lee et al., Voutsas, and Park et al.

Claims 22-29 and 54-61 were rejected under 35 USC 103(a) as being unpatentable over Lee et al. and Voutsas and further in view of Park et al.

Claim 22 recites a method for producing a wafer having a crystallized silicon layer with controlled defect density, the method comprising: forming a first layer of amorphous silicon on the wafer; selectively introducing a crystallizing agent on the amorphous silicon layer in a substantially symmetric pattern across a seeded area; and annealing the amorphous silicon layer, wherein, after the annealing step, in the seeded area, an area bounded by adjacent nucleation sites encloses no more

than five crystal grain boundaries.

The Examiner points to Fig. 1 (for example, Fig. 1(c) and 1(d)) as evidence that the area bounded by adjacent nucleation sites encloses no more than five crystal grain boundaries. It is true that in Fig. 1(c) only four grain boundaries are shown in the area bounded by any four adjacent nucleation sites. This is because only the crystallized regions 107 surrounding each nucleation site are of interest to Park et al., and only the grain boundaries of crystallized regions 107 are shown.

Applicants will maintain, however, that, referring to Fig. 1(c), one skilled in the art will appreciate that region 111, between crystallized regions 107, will have multiple grain boundaries which are not shown. As Park et al. describe (col. 7, lines 58-62), regions 111 are either amorphous or polycrystalline. In either case, there will be multiple additional grain boundaries in each of these regions. These grain boundaries are not shown because they are not important to the invention of Park et al., as Park et al. only teaches formation of TFTs within the boundaries of crystallized regions 107, as in Figs. 4(a) and 6(a) of Park et al.

As described in paragraphs [0062] and [0063] and accompanying Figs. 4a and 4b of the present application, the only way to guarantee that there will be no more than five grain boundaries in the area bounded by adjacent nucleation sites is to continue crystallization until the grain boundaries of adjacent crystallized regions meet, leaving no region like amorphous or polycrystalline region 111 of Park et al. There is no teaching in Park et al., however, that crystallization continues until the *entire* amorphous silicon layer is included in crystallized regions 107; in fact Park specifically shows and refers to regions 111 *between* and not included in crystallized regions 107. Thus there will be more than five grain boundaries in the area of Park et al. bounded by adjacent nucleation sites.

Applicants have shown that the suggested combination of Lee et al., Voutsas, and Park et al. does not teach each and every limitation of claims 22-29 and 54-61, and thus respectfully request reconsideration.

IV. Conclusion

The Examiner's prompt attention to this matter is greatly appreciated. Should further questions remain, the Examiner is invited to contact the undersigned attorney by telephone.

The Commissioner is authorized to charge any underpayment or credit any overpayment to Deposit Account No. 501826 for any matter in connection with this response, including any fee for extension of time, which may be required.

Respectfully submitted,

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